

TECHNICAL TRANSLATION

F - 39

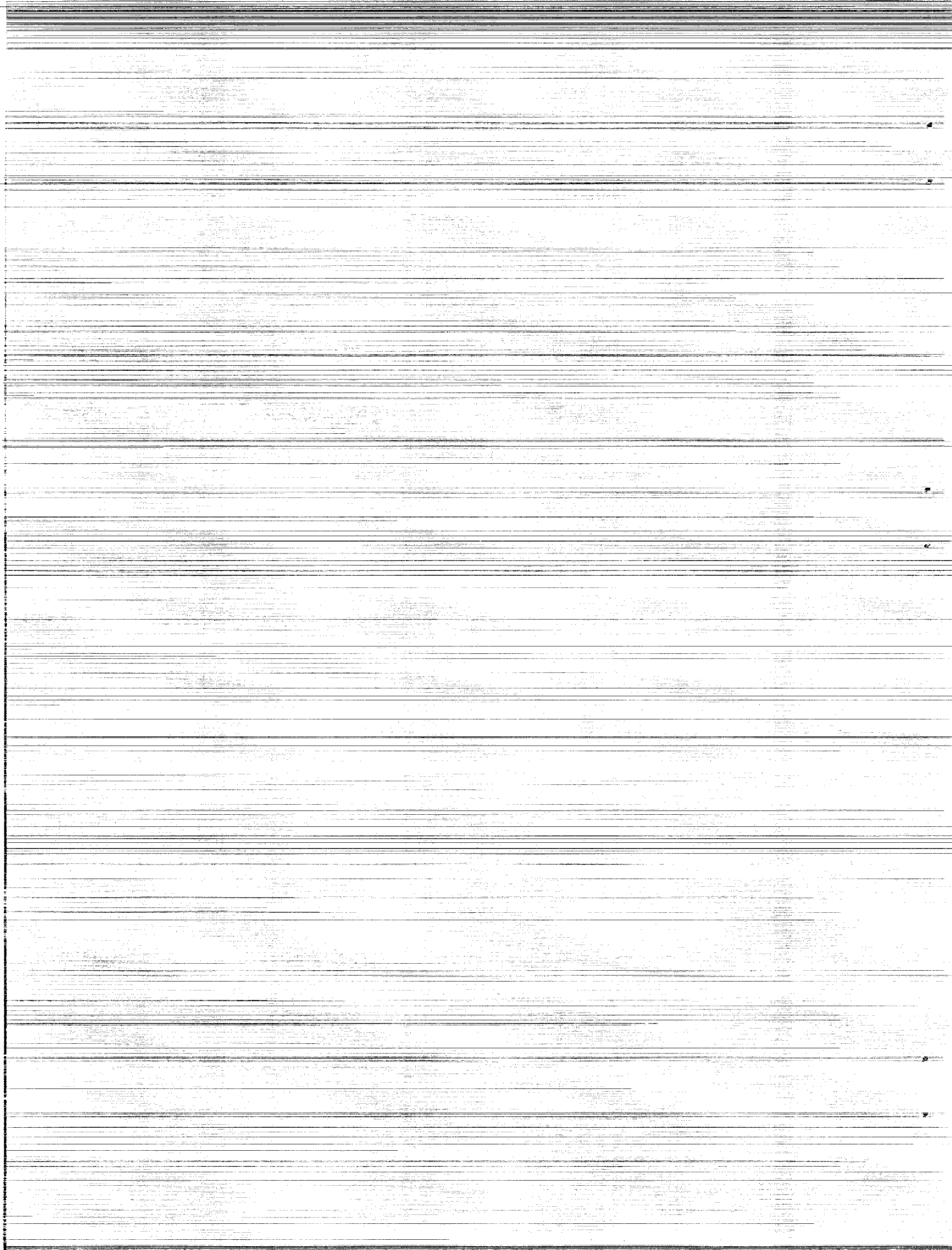
DISCOVERY OF ELECTRONS WITH AN ENERGY OF ABOUT 10 KEV
IN THE UPPER ATMOSPHERE WITH THE AID OF
THE THIRD EARTH SATELLITE

By V. I. Krasovskiy, I. S. Shklovskiy,
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A test aimed at the direct detection of not particularly hard electrons in the upper atmosphere was conducted aboard the third Soviet earth satellite launched on 15 May 1958 (refs. 1-3). A somewhat harder component of these electrons was investigated at a later date by other researchers (refs. 4 and 5). Similar experiments were also conducted with the aid of rockets in the aurora polaris (northern lights) region (ref. 6).

The experiment described here is characterized by the fact that practically only electrons with decimal kev energy rates were recorded. The measuring instrument used in the test did not record the X-ray radiation created by these electrons in the atmosphere and in the body of the satellite, since thin fluorescent screens (ZnS, activated Ag) containing 2 mg of compound per square centimeter of surface were used. These screens completely absorbed the above-mentioned electrons and only absorbed an insignificant amount of X-ray radiation. The recording instruments were not affected by protons with decimal kev energy rates, since aluminum foils (0.4 and 0.8 mg per sq cm) were placed in front of the screens. If X-ray radiation had been recorded, the data obtained would have yielded inaccurate information on the distribution of electron particles according to latitude and altitude. The upper earth atmosphere, particularly in the zone where aurora polaris occurs most frequently, is converted into a source (emitter) of X-rays under the action of electrons with the above-mentioned energy rates.

Approximately half of this radiation is unavoidably lost in outer space. For this reason, the instruments installed aboard a high-altitude rocket or a satellite will be subjected not only to the action of X-ray radiation arising in their body but also to the action of radiation

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present in the entire upper atmosphere. Since X-rays are generated most intensively in the vicinity of the zone of maximum aurora polaris recurrence, and since this zone becomes visible above the equator at a distance equal to about 2.5 earth radii (measured from the earth's center), the maximum flux of this type of radiation will be located in the vicinity of this zone. In other tests, X-ray radiation with good penetrating properties was also recorded, together with hard electrons and protons

Since we used aluminum foils of various degrees of thickness as absorbers, we were also able to estimate the "equivalent" electron energy, in addition to estimating the flux intensity of not particularly hard electrons. The recording instruments were calibrated for a wide energy range in a parallel flow of monochromatic electrons falling perpendicularly on fluorescent screens. Variations in electron energy resulted in changes of the radiation intensities, recorded by means of photocells, emitted by identical fluorescent screens. The flow of heterogeneous particles in the upper atmosphere also gave rise to different signals in both recording instruments. A definite energy value of monochromatic electrons corresponded to the observed ratio of signals, and this value was designated as the "equivalent" energy of electrons.

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As compared to electrons with an energy of 40 kev, the sensitivity

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first time during an investigation of the upper atmosphere, it has been possible to directly observe the presence of not particularly hard electrons with an energy of approximately 10 kev. Such electrons were recorded at altitudes ranging from 470 to 1,880 km above sea level. The lowest intensity was recorded over the geomagnetic equator at an altitude of about 1,300 km. At an "equivalent" energy of about 20 kev, the minimum current of such electrons is estimated to be approximately equal to 10^{-14} amp/sq cm per steradian. At medium and polar latitudes, up to 60° geomagnetic latitude, the usual current generated at night by electrons with an equivalent energy of about 12 kev is equal to $5 \cdot 10^{-11}$ amp/sq cm per steradian, and sometimes exceeds 10^{-10} amp/sq cm per steradian. Individual higher values of the recorded current were observed even at 4° geomagnetic latitude. It is interesting to note that the appearance of significant recorded currents is observed in the extraequatorial zone of increased ionization in the F region, described in reference 7.

When the experiment was set up, it was not expected that the intensity of electron streams would be so high. As a result, recordings were often beyond the instrument scale, and it was impossible to estimate the intensity and the "equivalent" energy of the recorded electrons. There were very few simultaneous recordings by two indicator devices whose scales were open for recording. Figure 1 shows the relation between the intensity of electron streams and their equivalent energy, measured during the night of 15 May 1958 over the southern part of the Pacific Ocean between $42^\circ - 54^\circ$ geomagnetic latitude at an altitude range of 1,720 to 1,880 km. The kev values of "equivalent" electron energy are plotted along the abscissa axis on a linear scale, and their "equivalent" current densities in amp/sq cm are plotted along the ordinate axis on a logarithmic scale, provided that these values correspond to a parallel electron flow, that is, without multiplying the measured values by $4 \text{ steradians}^{-1}$.

Concentric circles indicate recurrent values of equal intensities with identical "equivalent" particle energies. As the "equivalent" energy of the electrons increases, the number of such electrons declines rapidly.

Substantial changes in the intensity of electron streams took place during the rotation of the satellite around its two axes. However,

Higher values of "equivalent" electron energy were recorded at lower latitudes. The maximum recorded value was 40 kev. In polar regions, only the lowest values of the order of 10 kev were recorded.

It is possible to estimate the solid angle around a magnetic line of force within which charged particles penetrate into the atmosphere below a given altitude (ref. 8). For example, at a 50° geomagnetic latitude, the span of the critical solid angle which will allow particles to penetrate into regions below the F layer of the ionosphere from an altitude of 1,500 to 2,000 km must be equal to about 100° , which exceeds the scanning angle of the indicator devices. For this reason, it appears possible to estimate the entire flow of fast electrons which penetrate into lower atmospheric layers. Thus, for example, in case of minimum currents, this energy flow will be approximately equal to 1 erg/sq cm per second, which is quite sufficient to effect an additional ionization and heating of the upper atmosphere. The magnitude of this energy flow is close to the one, which, according to Bates (ref. 9) and Chapman (ref. 10), is required to maintain the temperature gradient in the upper atmosphere at a value of approximately 5° per km, and which cannot be provided by the hard electromagnetic radiation of the sun.

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Since the discovered electron streams exhibit the greatest intensity at higher geomagnetic latitudes, they can be assumed to cause the heating and expansion of the upper atmosphere, which was observed as the result of the slowing down of artificial earth satellites (refs. 11 and 12). The variations in the flow intensity of these electrons, which are apparently connected with solar activity, could explain the observed correlation between the magnitude of the braking effect exerted upon satellites and the integral effect of chromospheric flashes (ref. 13).

The stream of electrons with an energy of about 10 kev, which penetrates into lower atmospheric layers and which is absorbed by the layers, is so large that it cannot be due to the effect of cosmic rays (refs. 14-17).

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205 East 42nd Street, Suite 300,
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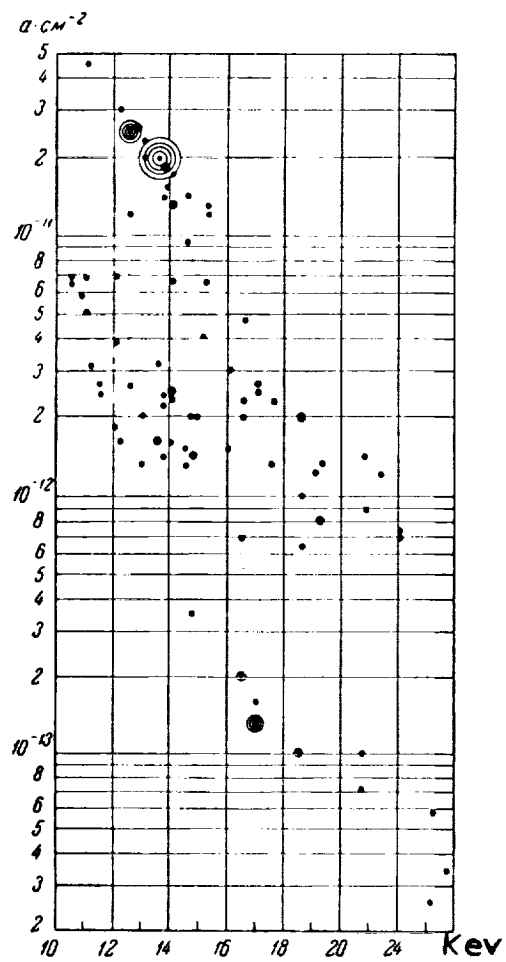


Figure 1.

